MDNR - NOAA Trawl Standardization Study

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Table of Contents

Introduction ………………………………………………………..………………………… 1

Methods ……………………………………………………..………………………….. 3

Results …..……………….…………………………………………………..…...…. 5

Discussion ..……………..………………………………..…………………….…... 6

Literature Cited ……………………………………..………………………..... 9

Tables and Figures ..………………………………..…..……………………… 11

Introduction

Long-term living resource monitoring programs are commonly conducted globally to evaluate trends and impacts of environmental change and management actions. For example, the Woods Hole bottom trawl survey has been conducted since 1963 providing critical information on the biology and distribution of finfish and shellfish in the North Atlantic (Despres-Patango et al. 1988). Similarly in the Chesapeake Bay, the Maryland Department of Natural Resources (MDNR) Summer Blue Crab Trawl survey has been conducted continuously since 1977 providing management-relevant information on the abundance of this important commercial and recreational species. A key component of monitoring program design is standardization of methods over time to allow for a continuous, unbiased data set. However, complete standardization is not always possible where multiple vessels, captains, and crews are required to cover large geographic areas (Tyson et al. 2006). Of equal issue is technological advancement of gear which serves to increase capture efficiency or ease of use. Thus, to maintain consistency and facilitate interpretation of reported data in long-term datasets, it is imperative to understand and quantify the impacts of changes in gear and vessels on catch per unit of effort (CPUE).

While vessel changes are inevitable due to ageing fleets and other factors, gear changes often reflect a decision to exploit technological advances. A prime example of this is the otter trawl, a common tool for fisheries monitoring and research worldwide. Historically, trawl nets were constructed of natural materials such as cotton and linen. However modern net construction consists of synthetic materials such as polyamide, polyester, polyethylene, and polypropylene (Nielson et. al. 1983). Over the past several decades, polyamide materials which will be referred to as nylon, has been a standard material used in otter trawl construction. These trawls are typically dipped into a latex coating for increased abrasion resistance, a process that is referred to as "green dipped."

More recently, polyethylene netting has become popular among living resource monitoring agencies. Polyethylene netting, commonly known as sapphire netting, consists of braided filaments that form a very durable material more resistant to abrasion than nylon. Additionally, sapphire netting allows for stronger knot strength during construction of the net further increasing the net's durability and longevity. Also, sapphire absorbs less water with a specific gravity near 0.91 allowing the material to float as compared to nylon with specific gravity of 1.14 (Nielson et. al. 1983). This same property results in a light weight net which is more efficient in deployment, retrieval and fishing of the net, particularly when towing from small vessels. While there are many advantages to the sapphire netting, no comparative efficiency data is available for these two trawl net types.

Traditional nylon netting has been used consistently for decades by the MDDNR to generate long term living resource data sets of great value. However, there is much interest in switching to the advanced materials. In addition, recent collaborative efforts between MDNR and NOAA's Cooperative Oxford Laboratory (NOAA-COL) require using different vessels for trawling in support of joint projects. In order to continue collaborative programs, or change to more innovative netting materials, the influence of these changes must be demonstrated to be negligible or correction factors determined. Thus, the objective of this study was to examine the influence of trawl net type, vessel type, and their interaction on capture efficiency.

Methods

Study location and design

Sampling was conducted in July of 2009 and 2010 on the Corsica River, a major tributary of the Chester River, located on the upper Chesapeake Bay. A random stratified design was employed, dividing the river into three equal sections by river mile. This design divided the Corsica into an upper and lower section, with a third section outside the Corsica on the main stem of the Chester River (Figure 1). In total, 24 random stations were sampled. Twelve stations were randomly sampled on each sampling date with four stations sampled in each of the three sections.

Two vessels were used in the study. The MDNR Blue Crab and Finfish Summer Trawl Survey used a 2004, 7.32 m Privateer, a fiberglass vessel outfitted with a forward cabin and a 225hp Evinrude Etech outboard mounted on an engine bracket. The MDNR vessel was outfitted with a 1.22 m “A Frame” for towing operations. Tow line attachment to the MDNR vessel was at the top of the “A Frame” approximately 1.22 m above the surface of the water. NOAA-COL used a 2003 7.01 m Parker, a fiberglass center console vessel outfitted with a 200hp four-stroke Yamaha outboard mounted without a motor bracket. The NOAA vessel lacks an “A Frame” hence the tow line was attached to transom eyes mounted on the stern of the vessel approximately 0.3 m above the surface of the water.

Each vessel towed one trawl using a parallel haul method as described by Revill et al. (2006). Trawls were towed for 6 minutes at 2.0 mph in a straight line 0.32 km transect directly into and against the direction of the tidal current. A random generation of left versus right side was determined for each vessel for each station transect. Both vessels towed two times for each net material type for a total of four random stations in each river section. Deployment of the trawls started simultaneously between both vessels once on station and when both vessels were in a position directly parallel to each other approximately 6 m apart. Trawls were manually deployed and retrieved consistently off of the same side of the vessel. Trawls were excluded and a duplicate was conducted at any station in which an obstruction was collected in the net that could potentially impact the ability of the trawl to fish correctly.

Otter Trawl Specifications

A 4.9 m semi-balloon bottom otter trawl (see Rupp and DeRoche (1960) for gear description) was towed by each vessel at each site. Trawl specifications were identical for each trawl except for net material type (Nylon vs. Saphire). Head ropes consisted of 5.18 m of 0.95 cm diameter rope with six sponge floats evenly spaced. Footropes consisted of 6.4 m of 0.95 cm diameter rope with 0.48 cm chain stretched along its length tied at 15.24 cm intervals. The body of the trawls consisted of either nylon or sapphire netting with 3.81 cm stretch and 1.91 cm bar mesh tied with No. 9 thread. Cod-ends consisted of 3.175 cm stretch, 1.59 cm bar mesh tied with No. 25 thread composing external chafing gear. An inside liner of 1.27 cm stretch, 0.64 cm bar tied with No. 63 thread was in place for sample collection. The trawl components were also identical. Trawls were opened by 31.75 cm x 50.8 cm otter doors outfitted with 0.79 cm shackles and 4.88 m of 0.635 cm tickler chain spread between the doors. Each door was linked to a bridle by a 5.18 m x 0.95 cm rope and then pulled by 30.48 m x 0.95 cm tow line.

Statistical Analysis

All catch and species richness data was log (CPUE+1) transformed prior to analysis to homogenize variances. Multi-way ANOVA was applied to species richness, and total fish, total crabs, white perch, juvenile white perch and juvenile blue crab abundances. The juveniles of fish and crustaceans were analyzed independently in order to examine size selectivity of the gear for these most abundant life stages. Main effects included in the analysis were sampling date, net type, vessel, and net x vessel interaction. Subsequent least square means (LS-means) comparisons were conducted when appropriate using Tukey's adjustment (SAS, LS Means, Pdiff option).

Results

Both trawls and vessels performed similarly in terms of total fish captured with sampling event (Date) explaining the majority of the variance (Table 1). Total CPUE was twice as high in 2010 (315.42 ± 36.63) than in 2009 (155.5 ± 18.53) (Figure 2). Similarly, total crab CPUE did not differ between gear, vessel, or sampling event (Table 2, Figure 3). Overall, an average of 20.52 ± 2.96 crabs were capture per tow with only two tows resulting in zero catch. The richness of organisms captured was also examined to evaluate gear selectivity. Again, no significant differences were noted in the number of species captured between trawl types, vessels, and sampling days (Table 3, Figure 4). However, the number of species captured was relatively low (3.19 ± 0.20). White perch were the most abundant and evenly distributed fish available in the river where we conducted this study and we analyzed this species independently as an appropriate marker for capture efficiency. While the MANOVA did not detect an overall significant effect on white perch CPUE (4,43 df, $f = 2.05$ $p = 0.10$), there was evidence of a marginal boat effect (1,47 df, $f = 4.19$ $p = 0.05$) (Table 5). The MDNR Privateer averaged 172.17 ± 17.26 white perch per trawl in comparison to 130.75 ± 18.41 for the NOAA Parker (Figure 6). Finally, we separated young-of-the-year (YOY) blue crabs and white perch to determine if either trawl or vessel was biased in terms of size selectivity. No bias was detected in YOY blue crab CPUE with both vessels and trawls performing equally (Table 4, Figure 5). However, sampling day, trawl, and boat x trawl interactions were all significant for juvenile white perch (Table 6, Figure 7). This is driven primarily by an inconsistent catch in 2010 (Figure 7). No juvenile white perch were captured in 15 of the 22 tows (68%) in 2010 with equal distribution among vessels. In 2009, juvenile white perch were captured in every trawl.

Discussion

By nature of the method and seasonal frequency, small vessel trawling programs are subject to a relatively rapid turnover of vessels, gear, and crew. For state and federal programs, this presents a challenge in maintaining the integrity of long-term data sets. To address this concern, we examined the influence of gear, vessels and their interactions in use by two collaborating programs to quantify changes in catch efficiency. Overall, gear, vessel, and their interaction accounted for the vast minority of total variance in comparison to that attributable to sampling event. These results suggest that the respective agencies have the flexibility to switch to the more durable and lighter weight Sapphire netting, and continue collaborative efforts from multiple vessels without concern for data continuity.

Sampling event was consistently the main source of variance. Total fish captured was nearly twice as high in the 2010 sampling event than in 2009 (Figure 2, Table 1). This is largely driven by recruitment variability of fishes and particularly juvenile spot (*Leiostomus xanthurus*). In 2009, spot were nearly absent compared to an average catch of over 150 per trawl in 2010. Maryland DNR Juvenile Finfish Seine Survey catch data shows a similar pattern in Bay-wide abundance of spot between 2009 and 2010 as the Bay-wide geometric CPUE of spot was over 6 times higher in 2010 than in 2009 (Durell 2010). Additionally, juvenile white perch frequency of occurrence was very low in 2010, including 15 stations with zero captures. Spot spawn offshore and enter the Chesapeake in the spring, while white perch are semi-anadromous (Murdy et. al. 1997). Hydroclimate factors may have a substantial influence on fish recruitment in Chesapeake Bay and affect coastal spawning fish differently than anadromous species as described in Wood and Austin's Chesapeake Bay Anadromous and Shelf-spawning (CBASS) recruitment pattern (2009). The dramatic difference in CPUE between years was consistent among vessels and gear eliminating these other sources of variability and providing additional support that recruitment variability plays a major role in controlling fish abundance and species composition in Chesapeake Bay and tributaries to the Bay.

No significant differences were noted in species diversity or in blue crab abundance. This was to be expected as there are only a few species available to the gear during the early summer in these locations. However, all were caught equally by both net types and vessels. Blue crab CPUE was not significantly different among vessels and trawls both in total number and more specifically for juveniles (Figures 3,5, Tables 2,4). This is especially encouraging for the MDNR Blue Crab Trawl Survey and their decision to switch to the Sapphire netting a few years prior. Our findings reported here suggest that this sampling decision did not jeopardize the continuity of the Blue Crab Trawl Survey time series.

Obstructions and debris in the trawled area is one potential source of error that must be accounted for in bottom trawl comparison studies because these factors may negatively influence the ability of the doors to open and restrict the net from fishing properly. In our study, we addressed this possible issue by conducting a duplicate tow when obstructions and debris were encountered. Nonetheless, this potential source of error cannot be ruled out completely. The use of acoustic and visual monitoring devices such as side-scanning sonar and underwater cameras would be valuable in future efforts for measuring the performance of survey nets to reduce obstruction-related sources of error in comparisons (Nielson et al. 1983).

The use of the Sapphire net material provides several key benefits. The durability and strength of Sapphire netting increases the life span of the net thereby minimizing gear replacement expenditures. In addition, the light weight characteristics of sapphire netting compared to the water absorbing tendency of nylon netting contribute to ease of deployment and handling. It was also noted in this effort that the sapphire material made it easier for catches to be funneled into the cod-end as compared to the nylon material.

In summary, our data suggests the Maryland DNR and NOAA’s Cooperative Oxford Laboratory can use both nylon and sapphire netting materials with either vessel in future sampling operations with minimal concerns about effects on long-term data consistency with realization of both positive economic benefits and increased sampling efficiency.

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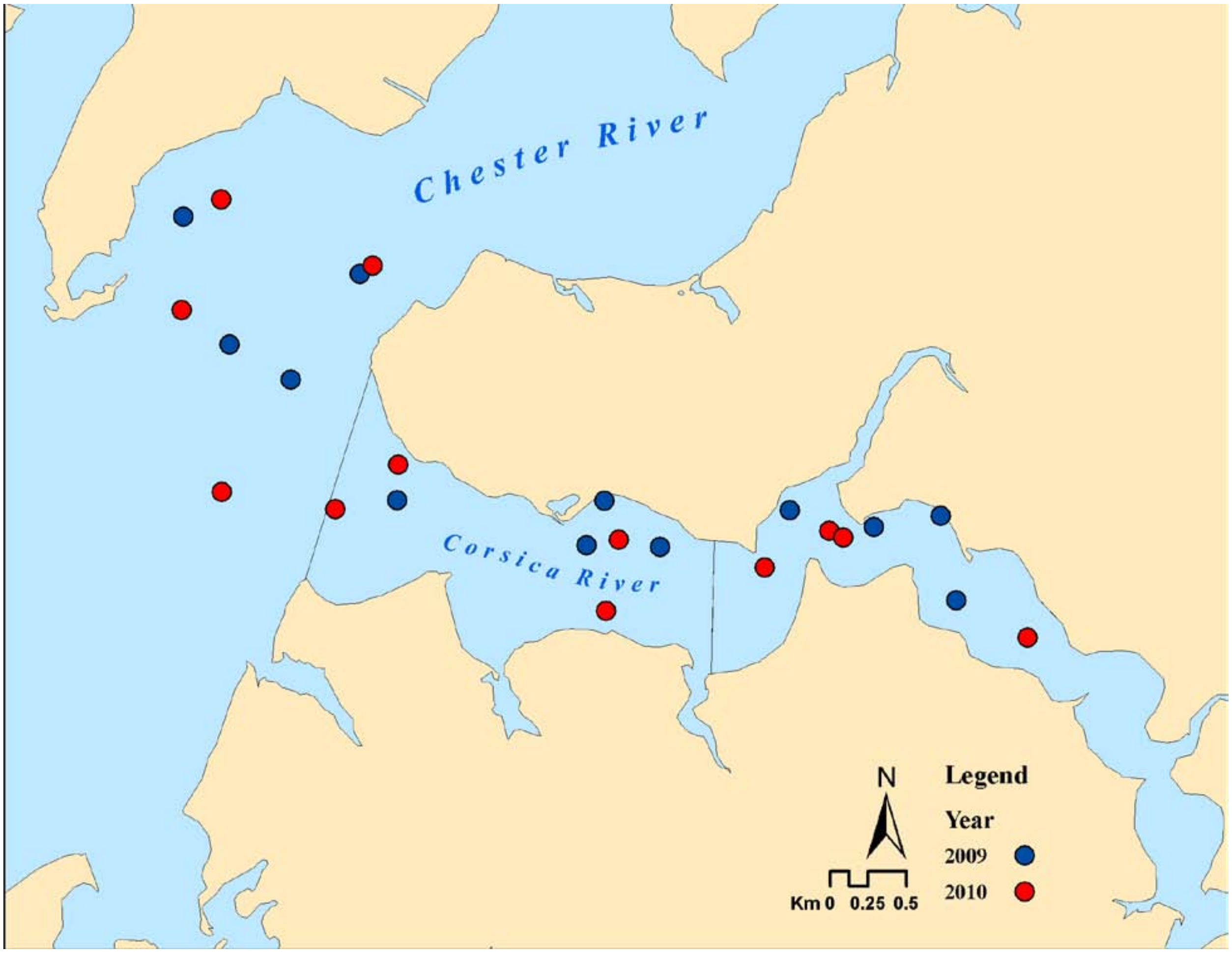

Figure 1 - Map of the Corsica River, Maryland study area. Sampling stations represent start of trawl transects.

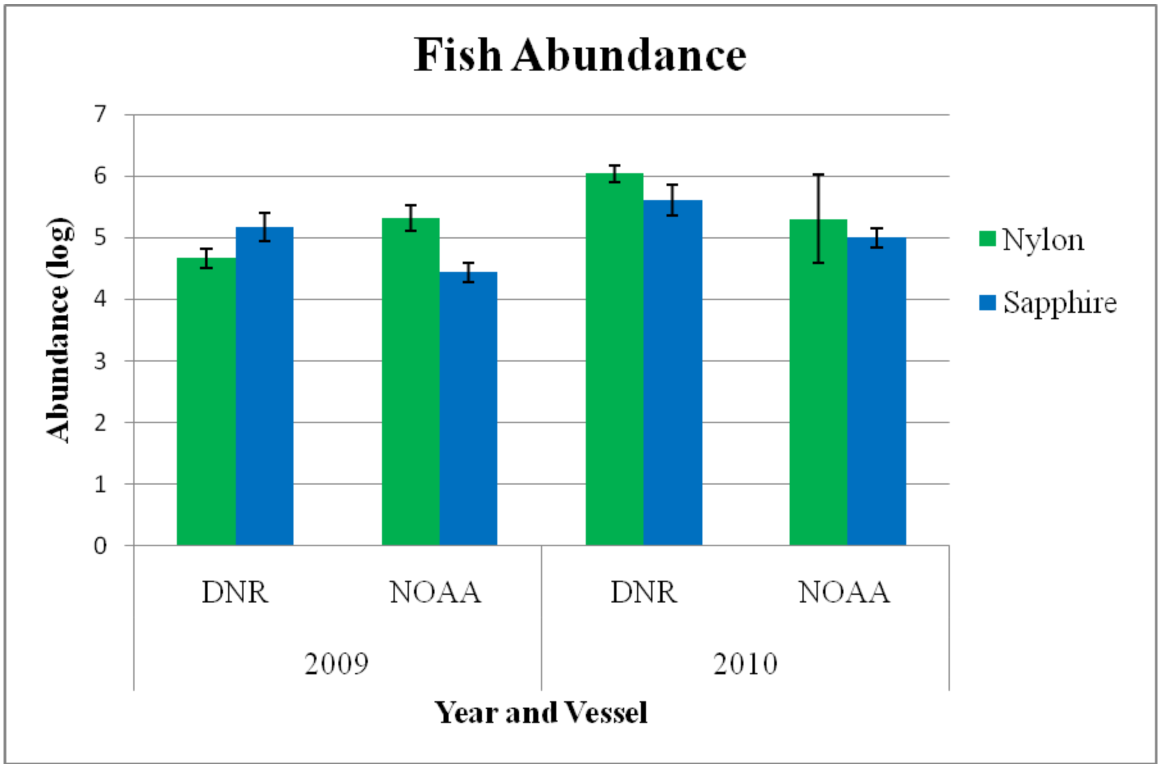

Figure 2 - Total fish captured by nylon (polyamide) and Sapphire (polythylene) net materials by vessel and year.

Fish Abundance	DF	MSE	*F*	*P*
Model	4/47	1.96	3.28	0.02
Error	43/47	0.60		
Date	1/47	4.16	6.94	0.01
Boat	1/47	1.58	2.63	0.11
Net	1/47	0.91	1.51	0.23
Boat*Net	1/47	1.21	2.02	0.16

Table 1 - Results of ANOVA comparing variance in total fish captured by date, boat, net, and boat by net interaction. Variance in Total Fish Captured with Date, Boat, Net, and Boat Net Interactions

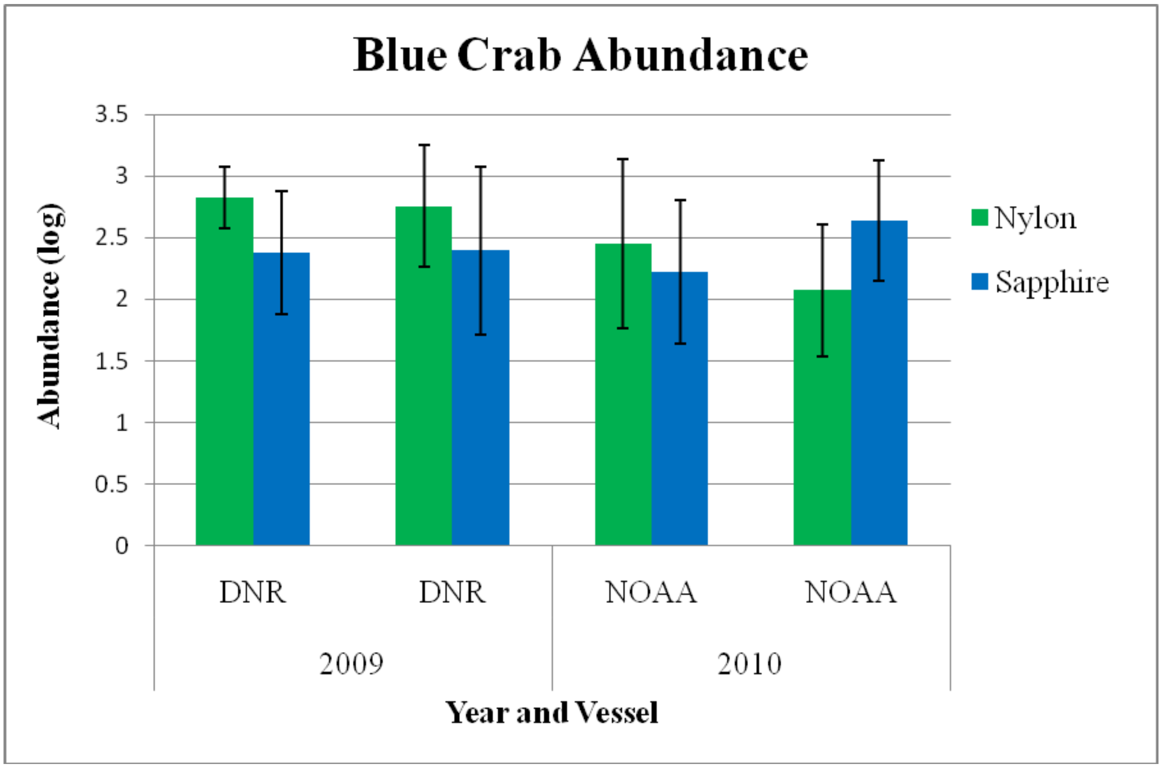

Figure 3 - Total Blue Crabs caught by nylon (polyamide) and Sapphire (polythylene) netting by vessel and year.

Blue Crab Abundance		DF	MSE	*F*	*P*
Model		4/47	0.36	0.22	0.93
Error		43/47	1.67		
	Date	1/47	0.71	0.43	0.52
	Boat	1/47	0.00	0.00	0.99
	Net	1/47	0.16	0.10	0.76
	Boat*Net	1/47	0.58	0.35	0.56

Table 2 - Results of ANOVA comparing variance in total Blue Crabs captured by date, boat, net, and boat by net Interaction.

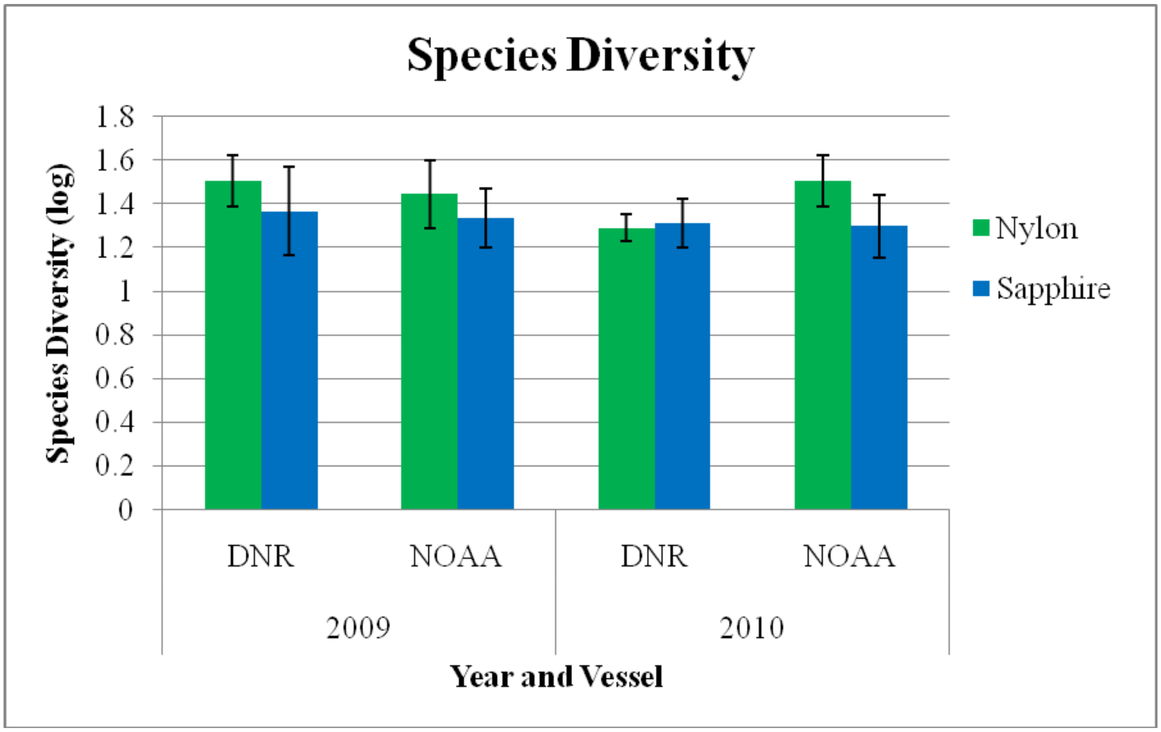

Figure 4 - Diversity of species caught by nylon (polyamide) and Sapphire (polyethylene) netting compared to vessel and year.

Number of Species				
	DF	MSE	*F*	*P*
Model	4/47	0.06	0.55	0.70
Error	43/47	0.11		
Date	1/47	0.05	0.44	0.51
Boat	1/47	0.01	0.09	0.76
Net	1/47	0.15	1.40	0.25
Boat*Net	1/47	0.03	0.28	0.60

Table 3 - Results of ANOVA comparting variance in species diversity by date, boat, net, and boat by net interaction.

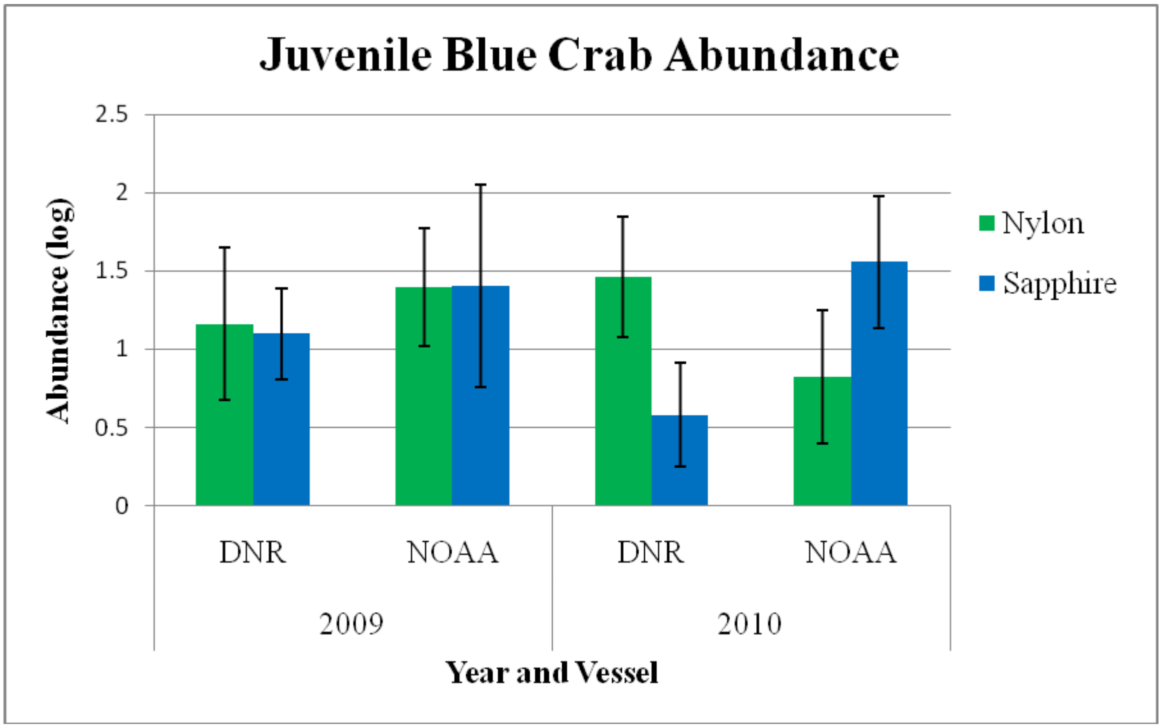

Figure 5 - Juvenile Blue Crabs (<60mm) caught by nylon (polyamide) and Sapphire (polythyelne) netting compared to year and vessel.

YOY blue crabs	DF	MSE	*F*	*P*
Model	4/47	0.76	0.70	0.60
Error	43/47	1.09		
Date	1/47	0.30	0.28	0.61
Boat	1/47	0.58	0.53	0.47
Net	1/47	0.03	0.03	0.86
Boat*Net	1/47	2.14	1.96	0.17

Table 4 - ANOVA comparing variance in juvenile Blue Crab captured by date, boat, net, and boat by net interaction.

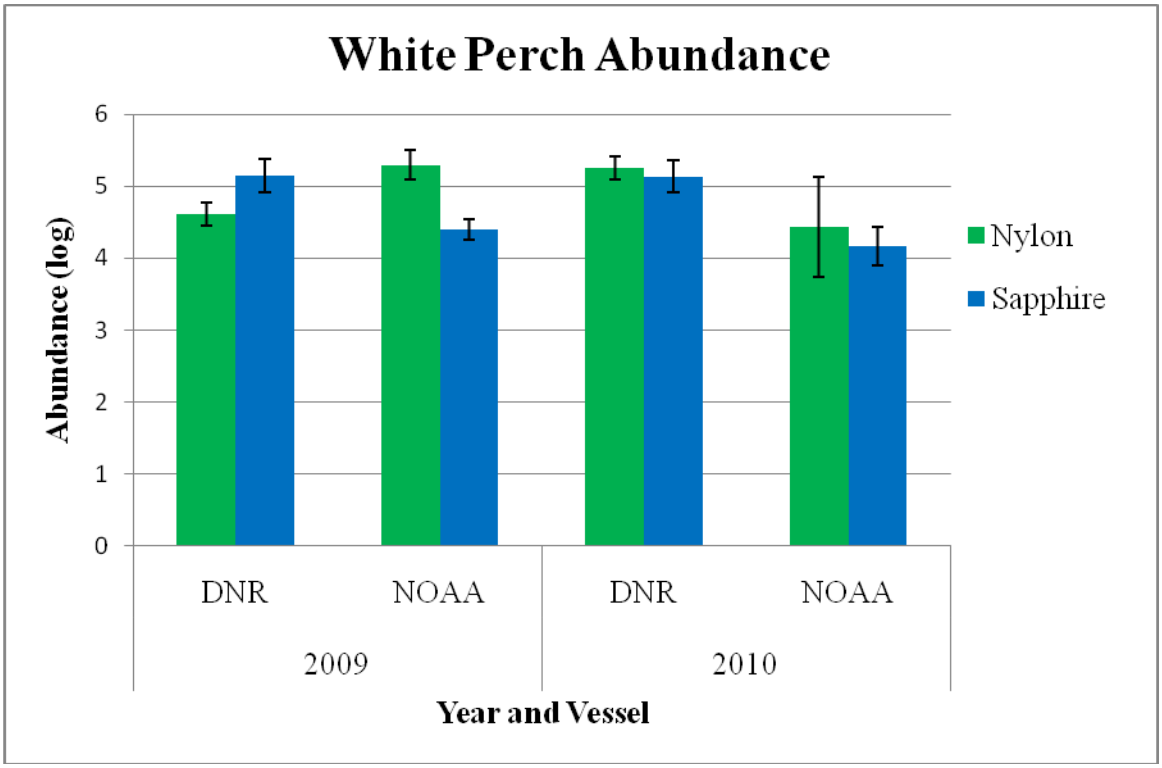

Figure 6 - Total White Perch caught by nylon (polyamide) and Sapphire (polyethylene) nets compared to year and vessel.

Adult White Perch		DF	MSE	*F*	*P*
Model		4/47	1.26	2.05	0.10
Error		43/47	0.61		
	Date	1/47	0.16	0.27	0.61
	Boat	1/47	2.57	4.19	0.05
	Net	1/47	0.43	0.71	0.41
	Boat*Net	1/47	1.85	3.02	0.09

Table 5 - ANOVA comparing variance in total White Perch captured by date, boat, net, and boat by net interaction.

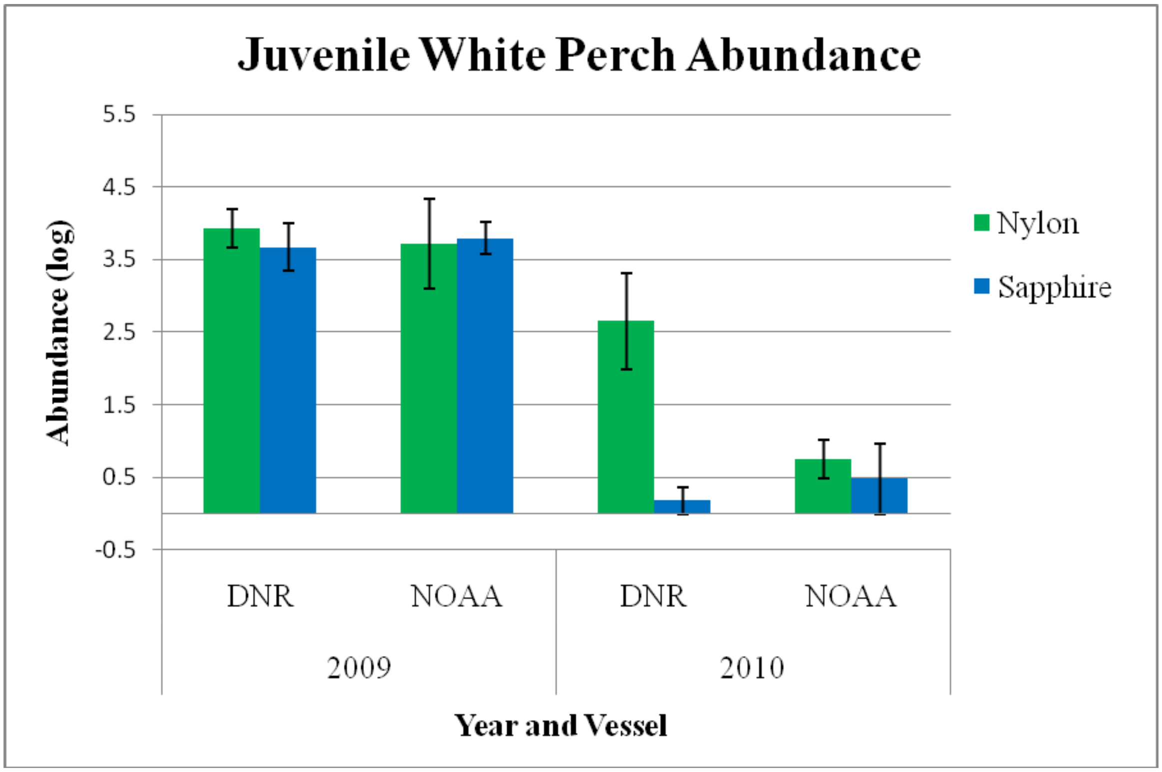

Figure 7 - Juvenile White Perch caught by nylon (polyamide) and Sapphire (polyethylene) nets compared to year and vessel.

YOY White Perch					
		DF	MSE	*F*	*P*
Model		4/47	26.21	22.18	<0.01
Error		43/47	1.18		
	Date	1/47	91.51	77.44	<0.01
	Boat	1/47	2.14	1.81	0.19
	Net	1/47	6.39	5.41	0.02
	Boat*Net	1/47	4.80	4.07	0.05

Table 6 - ANOVA comparing variance in juvenile White Perch captured by date, boat, net, and boat by net interaction.